Memorandum

To: Anne Summers, Port of Portland

From: Cynthia Lowe, PE and Karl Krcma, PE

Date: April 29, 2005

Subject: Floodway and Flood Storage Technical Explanation and Analysis

I. Introduction

The Port of Portland (Port) is required to perform a removal action at Terminal 4, which is located within the Initial Study Area of the Portland Harbor Superfund Site near River Mile (RM) 4.5 on the east bank of the Willamette River. The Port prepared a draft Engineering Evaluation/Cost Analysis (EE/CA) for the U.S. Environmental Protection Agency (EPA). In that report, the Port evaluates and ranks four alternative removal actions according to EPA criteria and guidance. One alternative, Alternative C, includes a confined disposal facility (CDF) in Slip 1, dredging of Slip 3, and capping at multiple locations, including a small area in the northeast corner of Berth 401, portions of the slope at Wheeler Bay, under the pier at Berth 411 and the nearshore slopes around Slip 3.

The purpose of this memorandum is to explain technical aspects of The Federal Emergency Management Agency (FEMA) flood hazard regulations in relation to the proposed removal action (Alternative C) at the Port's Terminal 4. Although FEMA does not regulate flood storage, the memorandum includes an analysis of potential flood storage impacts. You also asked us to evaluate whether the removal action would have an impact on the community flood insurance rating and discount in the City of Portland.

II. Floodway or Flood Rise Regulations

A. National Flood Insurance Program

FEMA developed the National Flood Insurance Program (NFIP) for floodplain management and flood insurance purposes in the early 1970s. To implement the NFIP, FEMA prepares Flood Insurance Studies (FIS) for waterways across the United States, which provides communities with flood elevations and floodplain boundaries.

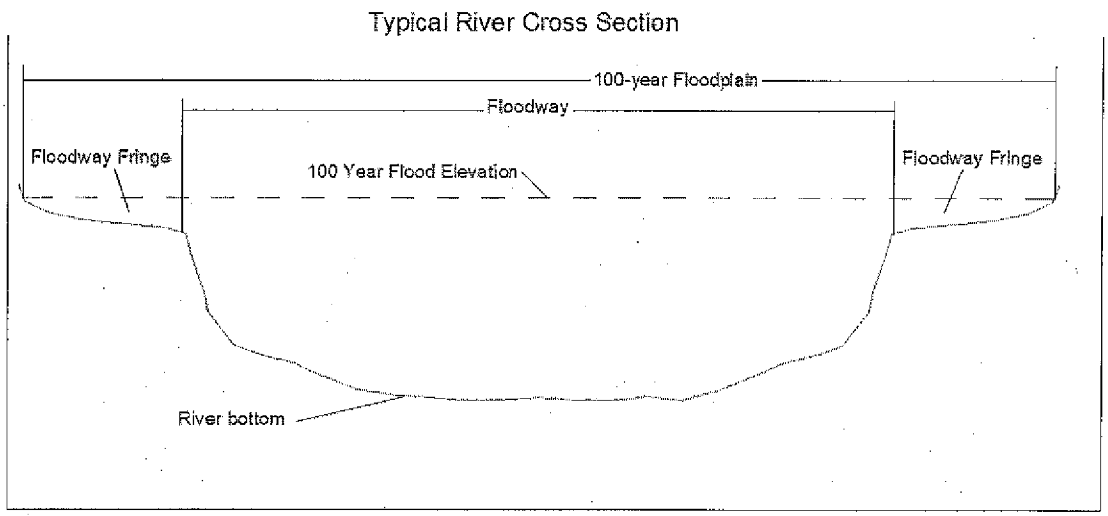
Floodplain/Floodway

The NFIP has adopted the 100-year flood as the national standard for floodplain management. For clarification, the 100-year flood is also termed the "base flood" or the one percent flood as the 100-year flood has a one percent chance of being equaled or exceeded in any year. In addition, the 100-year floodplain is defined as any land area susceptible to being inundated by water due to the base flood.

Recognizing the appeal of developing along waterways, FEMA developed the concept of a floodway as a floodplain management tool for communities. The floodway concept involves dividing the 100-year floodplain into two components: a floodway and a floodway fringe. The floodway represents the main channel of the waterway and any overbank area needed to convey the 100-year flood without causing an unacceptable increase to the 100-year flood elevations. The minimum Federal standard limits the allowable flood elevation increase to one foot above the 100-year flood elevation at any location along the waterway. Communities that adopt the FEMA floodway and participate in the NFIP must enforce FEMA regulations prohibiting placement of fill or structures within the floodway unless it can be shown that the proposed development does not increase the base flood elevation.

The floodway fringe represents the balance of the 100-year floodplain that does not lie within the floodway (Figure 1). The NFIP does allow fill to be placed within the floodway fringe, recognizing that the fill's impacts on flood elevations is managed through the floodway concept. Based on the definition of the floodway, the floodway fringe could be completely filled on both sides of a waterway and not increase the 100-year flood elevations by more than one foot at any location.

Figure 1.



The floodway is typically calculated for FEMA flood studies using the U.S. Army Corps of Engineers Hydrologic Engineering Center computer programs HEC-2 and HEC-RAS. HEC-2 was developed in the mid 1970's and uses a standardstep backwater calculation to determine water surface profiles. HEC-RAS (River Analysis System) is an updated version of HEC-2 that incorporates, among other enhancements, a graphical user interface. Both programs are one-dimensional and model the geometry of the river by cross sections aligned perpendicular to the flow of the river. Water surface profiles are determined by interpolating between the model's cross sections.

FEMA Floodway Regulations

The following quote is taken directly from the FEMA NFIP Regulations for Floodplain Management and Flood Hazard Identifications, Code of Federal Regulations (CFR):

> *44CFR §60.3(d)(3) Prohibit encroachments, including fill, new construction, substantial improvements, and other development within the adopted regulatory floodway unless it has been demonstrated through hydrologic and hydraulic analyses performed in accordance with standard engineering practice that the proposed encroachment would not result in any increase in flood levels within the community during the occurrence of the base flood discharge;*

This regulation is commonly referred to as the "no rise" criteria. The intent of the regulation is to prevent any impedance to the conveyance of floodwaters within the floodway. By protecting the floodway and hence a waterway's conveyance, the "no rise" criteria provides upstream property owners with protection from increased floodway levels due to downstream development.

If the hydrologic and hydraulic analyses indicates an increase in flood levels due to the proposed encroachment in the floodway, provisions exist to still allow the development in the form of mitigation. Most commonly, the loss of conveyance due to the proposed development is mitigated by compensating actions to restore lost conveyance, such as dredging, reshaping the banks through grading, removing obstructions, or other reductions to improve the flow of floodwaters. One condition FEMA imposes for mitigating compensation is that it must be maintained for perpetuity.

Alternatively, FEMA has provisions for revising a floodway boundary via redelineation. The floodway revision process tends to be rather lengthy due to the public approval period, FEMA's technical review, and the hydraulic analysis required. Technically the floodway could be revised (narrowed) as long as the one foot flood elevation increase is not exceeded at any point along the waterway.

The City of Portland follows FEMA guidelines for controlling development in the floodplain, and the City has adopted ordinances which FEMA designed to reduce future flood losses. The City's flood rise management ordinance is found at PCC 24.50.060.D of the city's zoning ordinances. This ordinance follows the FEMA CFR in essence and provides the City a means to enforce the FEMA NFIP "no rise" regulation. The ordinance also fulfills a FEMA requirement to allow the community to purchase federal flood insurance through the NFIP.

C. Application to Terminal 4 Removal Action

According to FEMA, no increase in the base flood elevation can result due to placement of fill or placement of structures within a floodway. Consequently, if the CDF or sediment caps are placed within the floodway boundary, this would require an analysis to demonstrate that the encroachment into the floodway will not increase the base flood elevation.

Two of the three cap placements proposed encroach into the floodway. For the two floodway encroachments, one cap is located near the downstream end of Berth 401 and the other near the upstream end of Slip 3. Based on the conceptual design, only around 2,000 square feet of cap placement intrudes into the floodway at Berth 401 and approximately 470 square feet near Slip 3. A HEC-RAS model was used to analyze the proposed cap placements. The HEC-RAS modeling results indicated no rise in the base flood elevations due to the proposed cap placements. This is documented in PB's letter to the Port dated March 11, 2005.

The proposed CDF in Slip 1 is in the floodway fringe, but outside of the floodway limits. Therefore, according to FEMA regulations, the fill is allowable. The fill also meets the requirements of City of Portland floodway ordinance (PCC 24.50.060.D). Even though the CDF does not encroach within the floodway, a HEC-RAS analysis was still performed to assure that the CDF would not cause a rise in the base flood elevations. The results of the analysis indicated that no rise resulted from filling the slip based on the conceptual design. This is also documented in PB's letter to the Port dated March 11, 2005.

III. Flood Storage Evaluation

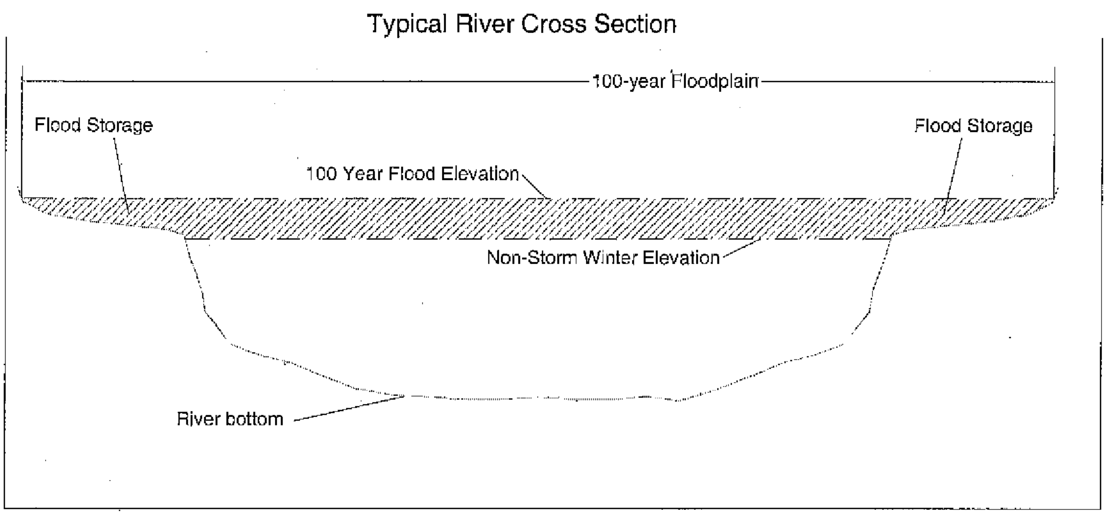
FEMA does not have a regulation regulating flood storage, but some communities, including the City of Portland, have adopted ordinances to preserve flood storage to ensure that the quanity of water reaching the watercourse (and ultimately downstream property) is not increased. PCC 24.50.060.F.8. Although the City of Portland ordinance is not an applicable, relevant or appropriate requirement (ARAR) for the Terminal 4 removal action, an analysis of flood storage impacts was conducted to ensure that the removal action will not increase flood hazards to downstream property owners.

A. Flood Storage

Flood storage refers to the temporary filling of overflow areas or retention/delay of runoff during a flood event. Typically a rainfall storm event occurs such that the rainfall runs overland, after saturating the ground, and eventually into a stream. If the overland flow is high enough or takes place over a long enough period of time, the capacity of the stream is exceeded. Floodwaters that spill out of the stream's banks flow into overflow (floodplain) areas. The water that is spilled into the overbank areas is temporarily "stored", thus reducing the quantity of flow downstream in the main channel of the stream. As the flood recedes, the overland areas drain back into the stream.

The area available for flood storage is the area above the stream level just preceding the storm event, termed the non-storm winter stage, up to the 100-year flood elevation, as shown in Figure 2. Because the area below the non-storm winter stage is already inundated when the storm event occurs, it provides no flood storage during a storm event.

Figure 2.



An example to compare the effects of flood storage is the difference between typical streams in rural versus urban settings. The rural stream would typically have more overland storage due to less development of the floodway fringe areas, resulting in some floodwaters temporarily held in the overbank areas. However, the typical urban stream would have less storage due to floodway fringe development, which would confine the floodwaters to the main channel, resulting in a quicker rise of water surface and a greater peak discharge. In summary, the flood event without storage rises quicker and would have a slightly greater peak discharge than a flood event on a stream with greater flood storage.

The effectiveness of the flood storage, however, is not the same for every stream. The effectiveness depends upon the size of the drainage basin, the amount of storage, the location of the storage, characteristics and timing of the design storm event, and characteristics of the riverine hydraulics. For example, Johnson Creek in the Portland Metro area has a drainage basin of 54 square miles. The 100-year flood event on Johnson Creek has a peak discharge of 2,780 cubic feet per second (cfs) and the flood generally takes place over 24 hours or less. The drainage basin of the Willamette River is 11,600 square miles with a 100-year peak discharge of 375,000 cfs and a duration of the flood event occurring over 2 days or more. An effective overbank flood storage volume of 300,000 cubic yards (cyd) would have the effect of reducing the time of flooding on Johnson creek 48 minutes versus 22 seconds on the Willamette River. A 300,000 cyd flood storage volume would probably provide a noticeable difference to the peak discharge and consequently reduced flood impacts downstream on Johnson Creek; however, the same volume would not provide a noticeable difference to peak discharge or downstream impacts on the Willamette River.

B. Evaluation of Terminal 4 Removal Action

CDF

A portion of the CDF will be located above the non-storm winter stage and some flood storage will be lost by placement of the CDF. However, the lost flood storage from filling Slip 1 has an insignificant effect in reducing flood hazard due to the relative size of the Columbia and Willamette River drainage basins, the location of Terminal 4, the amount of storage provided by Slip 1 relative to the drainage basin, the duration of the flood events on the Willamette River, and the riverine hydraulics.

Terminal 4 is located near the outlet of the Willamette River drainage basin. The drainage basin of the Willamette River is 11,600 square miles with a 100-year peak discharge of 375,000 cfs and a duration of the flood event occurring over 2 days or more. In addition, the hydraulics of the lower Willamette River is impacted by backwater effects from the Columbia River which encompasses an even larger drainage basin than the Willamette River.

The regulatory 100-year flood elevation on the Willamette River is computed by analyzing river stage statistics for the Portland harbor and the Columbia River. Two types of flooding can impact Portland harbor:

1) Willamette River floods that usually occur in winter months (around November through February) and
2) Columbia River floods that usually occur during spring freshet (May through July).

The drainage basin of the Columbia River above the confluence with the Willamette River is approximately 241,000 square miles, and the modeled 100-

year discharge is 565,000 cfs. Since the 100-year elevation is computed on stage statistics, the discharge for purposes of modeling a floodway on the Willamette and Columbia Rivers is determined by modeling various flows until the statistically determined stage is achieved. The dominating elevation for the 100-year flood in the vicinity of Terminal 4 is actually the backwater from the Columbia River flood.

The volume of potential flood storage that would be lost as a result of the CDF construction was calculated. Digital bathymetry and topographic information supplied by BB&L, Inc. was utilized to develop a digital terrain model of the site. For purposes of comparison, two volumes were computed:

1) the difference between the 100-year flood elevation and ordinary high water (OHW) representing the bank full stage, and
2) the difference between the 100-year flood and the 50% exceedance (high tide) stage for Portland harbor, representing an "average" river stage.

Table 1 lists the results for the two volumes and includes the time required to fill the storage volume during the 100-year flood event. The previously stated 100-year discharge for the Willamette River in the T-4 reach of 375,000 cfs was used to calculate the fill time.

Table 1. T-4 CDF Flood Storage Calculations

Description	Volume (cyds)	Time to fill (seconds)
OHW to 100-year	265,700	19
50% exceedance to 100-year	458,000	33

Using the Johnson Creek example as a comparison, assume that 458,000 cyds of flood storage is lost. That would equate to X hours of storage on Johnson Creek for a flood that takes place over 24 hours or less versus 33 seconds on the Willamette River by Terminal 4 for a flood that lasts two days or more. On Johnson Creek the storage would probably be effective in reducing downstream peak flows; however, on the Willamette River at this location, the flood storage of 458,000 cyds is insignificant and would result in no noticeable increase in peak discharge.

This conclusion is further highlighted by comparing the flood storage at Slip 1 to the flood storage of the overall system. Since the 1930's, Federal and private dams have been built in the Willamette and Columbia River drainage basins to store water for flood control, generate hydroelectric power, and for other purposes. There are 32 major reservoir projects operated by the Corps of Engineers, in addition to 45 other non-federal projects including three Canadian reservoirs. The combined flood storage of the system exceeds 39 million acre-feet of storage. A storage volume of 458,000 cyds equals approximately X acre-feet. Compared to upstream flood control storage projects, the X acre-feet is only 0.00X% of the total storage (39 million acre-feet). Consequently, the loss of flood storage at Terminal 4 would not have a noticeable impact downstream.

Based on these factors, Slip 1 provides insignificant effective flood storage at this location on the Willamette River and the loss of flood storage from the CDF would not have a noticeable impact downstream.

Capping

Capping is proposed at multiple locations in T-4 including a small area in the northeast corner of Berth 401, portions of the slope at Wheeler Bay, under the pier at Berth 411 and the nearshore slopes around Slip 3. Based on information from BBL, the preliminary capping thickness is three feet at Berth 401 and Wheeler Bay and three to four feet at Slip 3. No flood storage would be lost because the cap as proposed will be placed below the non-storm winter stage. In other words, because the location of the proposed cap is already inundated before the floodwaters arrive, no storage would be lost by placement of a cap, and consequently no impact on flood storage would occur.

C. Portland's Flood Insurance

While FEMA does not have a flood storage regulation, FEMA has a Community Rating System (CRS) as a part of the NFIP that credits communities for various floodplain management criteria. The City of Portland receives some credit for flood storage protection through the CRS. You asked us to also evaluate whether removal of the flood storage at Slip 1 would have an impact on the City of Portland's flood insurance rating and discount.

The CRC implements a point system that awards points based on a total of 18 floodplain management activities which are organized under four general areas: 1) public information, 2) mapping and regulations, 3) flood damage reduction, and 4) flood preparedness. The point system determines the class rating and discount applicable in the community. The City of Portland is rated as a Class 6 CRS community and receives a 20% discount on flood insurance due to their rating.

Some criteria for Portland's CRS rating include but are not limited to: having a requirement that homes are elevated a minimum of one foot above the base flood elevation, providing open space along waterways, participating in a repetitive loss program, and having a balanced cut and fill ordinance (PCC 24.50.060.F.8). The Class 6 rating requires a total of 2,000 to 2,499 points, of which a provision for compensating storage awards up to 70 points. According to FEMA's last verification, the City of Portland has a total of 2,194 points in the CRS rating. Of the 2,194 points, the City received 28.7 points for the balanced cut and fill requirement in PCC 24.50.060.F.8. Even if the removal of the flood storage at Terminal 4 caused the NFIP to take away the City's points for this category, which is not likely, the City of Portland would retain its Class 6 rating.

IV. Conclusions

As modeled using HEC-RAS, the proposed caps and CDF at Terminal 4 result in no increase to base flood elevations, thus fulfilling FEMA regulations and the City of Portland 24.50.060 provisions for flood hazard reduction.

The caps are proposed to be placed below the OHW water level; therefore, the capping would not remove any flood storage from the Willamette River basin..

The proposed CDF does remove flood storage, however, due to the insignificant volume compared to the Columbia/Willamette drainage basins, no noticeable impact to flooding in the Willamette River would occur as a result of the CDF.

REFERENCES

City of Portland, Code and Charter, Title 24 Building Regulations, Chapter 24.50 Flood Hazard Areas, February 4, 2005

Code of Federal Regulations, Title 44, Emergency Management and Assistance, Revised October 1, 2004

Federal Emergency Management Agency, Flood Insurance Study, City of Portland, Oregon, Revised October 19, 2004

Metro, Title 3 Model Ordinance, Growth Management Committee, May 28, 1998

U.S. Army Corps of Engineers, February 1996 Postflood Report, Hydrometerorological Evaluation, September 1997

U.S. Geological Survey, Water-Data Report OR-03-1, Water Resources Data Oregon Water Year 2003, June 2004